no longer accept any statement, no longer receive any reading, however strongly supported by authority or backed by ancient tradition, unless it be corroborated by the potent instrument of comparison. The modern scientific method is the bar before which our classical studies must all be brought.

The truth of this may be seen at once by comparing the contents of our modern philological periodicals with those that were published at the beginning of the present century. The material still remains the same, but the spirit, the method, and the aims have all been changed. In this, as in the science of language itself, Germany has led the way; but the example of Germany has now found able imitators both in this country and in America. The English *Journal of Philology* has been too long in existence for its merits to need more than a passing recognition, and the *American Journal*, the first number of which has just appeared under the editorship of Prof. Gildersleeve, promises to be a worthy rival of its English forerunner. At present, indeed, most of its articles have a touch of "rawness" inseparable from a new venture, but a large part of it is occupied in a most useful way by an analysis of the articles that have been published in kindred foreign serials. This is a feature that might be imitated with advantage by the English *Journal*. Both publications admit Oriental and general as well as purely classical subjects, and an article in the last number of the English *Journal* by Prof. Robertson Smith on "Animal Worship and Animal Tribes among the Arabs and in the Old Testament," is marked by his usual learning and acuteness. He shows in it that Mr. Maclennan's theory of a primitive totemism in connection with polyandry is fully confirmed by the early beliefs and practices of the Semites. A new light is thus cast upon the beginnings of Semitic religion, and obscure allusions in the Old Testament are cleared up. A. H. SAYCE

OUR BOOK SHELF

Fern Etchings: Illustrating all the Species of Ferns Indigenous to the North-Eastern United States and Canada. Second Edition. By John Williamson. (Louisville, Ky., 1879.)

A HANDSOME book, consisting of etchings, with accompanying letter-press descriptions, of sixty-eight species or varieties of ferns, natives of the northern part of the American continent. The drawings are well executed and characteristic, giving a faithful idea of the general habit of the fern, though without any enlarged details; and the accuracy of the descriptions is insured by borrowing them from Gray's "Manual" or Eaton's "Ferns of North America." Of the species depicted, including all that are natives of the Northern United States and Canada, twenty-two, or about one-third, are also natives of the British Isles. The southern limit for the volume appears to be Virginia and Kentucky. The volume is an elegant ornament to the drawing-room table.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

A Fourth State of Matter

IN the very interesting communication from Mr. Crookes on "A Fourth State of Matter," which is contained in NATURE, vol. xxii. p. 153, there is a paragraph at the end which advances, as it seems to me, some most disputable propositions.

Like many other questions of modern science, the question he raises is to a very large extent a question of definition. But questions of definition are questions of the very highest importance in philosophy, and they need to be watched accordingly.

Speculating on the ultimate conceptions of Matter which are affected by the discovery of it in "a fourth condition," Mr. Crookes says: "From this point of view, then, Matter is but a 'mode of motion.'"

It has never appeared to me that this well-known phrase is a very happy one, even as applied to Heat. It is possible, of course, to consider Heat from this point of view. But then it is equally possible to consider all other phenomena whatever from the same point of view. Not only Heat, but Light, Sound, Electricity, Galvanism, and Sensation itself in all its forms, may be regarded as "modes of motion."

But at least in the application of this phrase to Heat there is an intelligible meaning, and not a mere confusion of thought. But as applied to Matter—as a definition of our ultimate conception of Matter—it appears to me to confound distinctions which are primary and essential. "Motion" is an idea which presupposes Matter and Space. Motion has no meaning whatever except the movement of Matter in Space. To define Matter, therefore, as a "mode of motion," is to define it as Matter in a state of motion. But this definition necessarily implies that Matter can also be conceived as without motion, and accordingly Mr. Crookes is obliged to confess that "at the absolute zero of temperature inter-molecular movement would stop," and that after that, Matter would remain with all the "properties of inertia and of weight."

Again, Mr. Crookes says: "The space covered by the motion of molecules has no more right to be called Matter than the air traversed by a rifle-bullet can be called lead." No doubt this is true; but it implies what is not true, that the common idea of Matter is nothing but "the space covered by the motion of molecules." The popular ideas attached to words of primary significance may not be always adequate or complete. But in my opinion they are generally much more near the truth and more accurately represent the truth, than most of the phrases which scientists are now inventing in the region of transcendental physics.

These phrases have their value and their interest as representing special and partial aspects of phenomena. But I hold that the unconscious metaphysics of human speech are often the deepest and truest interpretations of the ultimate facts of nature.

June 20 ARGYLL

The Fine Wire Telephone

I HAVE just read in NATURE, vol. xxii. p. 138, an abstract of the *Proceedings* of the Royal Society of London, giving an account of a new form of telephone receiver devised by Mr. Preece.

It happens, very curiously, that I was led independently to construct a practically identical instrument, with which I have been experimenting for some time in the laboratory of my colleague, Prof. Tait, and which was exhibited in action at the last meeting of the Royal Society of Edinburgh, before I was aware of Mr. Preece's invention.

The experiments of Mr. Preece and myself have been to a considerable extent anticipated by some results given in a paper by Dr. Ferguson (*Proc.* R. S. E., 1877-78, pp. 628 *et seqq.*), of which I was unaware when I made my own experiments.

It is true that Dr. Ferguson has not applied his apparatus to the transmission of music or of articulate sounds, as has been done by Mr. Preece and myself; but he made the practically very important step of attaching a mechanical telephone to the wire which conveys the varying current, and has thus rendered the observation of De la Rive's sounds in iron and other metals both easy and certain.

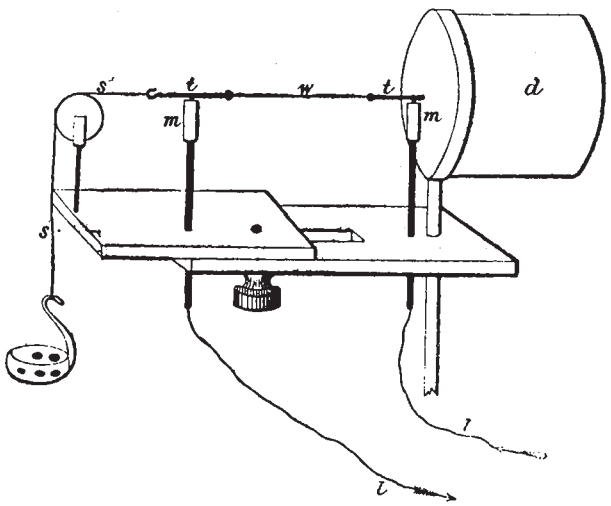
In Dr. Ferguson's paper will also be found a most important result, which I have verified since he drew my attention to it, viz., that sounds can be produced in fine wires generally by induction currents of very feeble total heating effect.

As to the theory of the action of this new kind of receiver, I agree with Mr. Preece that in weakly magnetic metals generally it is due to heating effects. I had been discussing with Mr. Blyth the theory of his receiver (described in NATURE, vol. xix. p. 72), and it was as an illustration of the explanation of all kinds of microphone receivers, suggested by his beautiful experi-

ments on loose contacts, that I thought of the experiment in question. My idea was to replace his heated point of metal by a continuous portion of the circuit which should act in the same manner. It was obvious that this part must be of small diameter to secure resistance enough to make the extension of the wire due to the variation of the heating effect sensible; and to insure that the cooling should be rapid enough to allow a musical note to be produced.

I had reason beforehand to believe that the second condition could be fulfilled in practice; because I had found in my experiments on Ohm's Law (*Reports*, British Association, 1876, p. 58, *et seq.*) that, when currents of different strengths alternated very rapidly in a fine wire, the cooling was so rapid that the resistance was sensibly greater during the passage of the strong current than it was during the passage of the weaker.

The accompanying figure represents the apparatus with which I worked. I generally used a microphone attached to a violin, belonging to Mr. Blyth, for a transmitter. In this way music was reproduced so as to be audible all over Prof. Tait's large class-room. For reproducing articulate speech I have found a small mica diaphragm, like that used by Edison, Blyth, and others, best; words spoken to the violin are reproduced in this way quite intelligibly, but as I do not possess a good microphone transmitter, I have not experimented much in this direction.



w, fine wire; *t t*, thicker copper terminals; *m m*, mercury cups over which *t t* pass; *s s*, string kept tight by small load; *l l*, line wires to microphone; *d*, drum head which distributes the sound.

So far as the limited supply of fine wire permitted, I had arrived substantially at the same results as Mr. Preece regarding the length and tension of the wire. My best results were got with a very fine silver-palladium wire given me by Prof. Tait; with it I could see the string s s move in time with the swell of the music. I also used a thicker and shorter platinum wire, heated by the current to a dull red, during silence; it was beautiful to see this wire burst into a bright glow when there came a prolonged note, more especially a high one.

Dr. Ferguson, in the paper above referred to, regards these effects as not due to heating (although he seems to think they follow the same law), but as being molecular in some other sense not very clearly defined. Except in the case of iron,[1] I do not see at present any necessity for so regarding them. The fact that induction-currents of small heating effect will produce them is not conclusive; for it must be remembered that it is not the *whole* heating effect, but the *variation* of it during a very short interval that is in question, and some calculations from rough data in my possession have led me to think that there would be no inconsistency in explaining Dr. Ferguson's ticks and the speech and music in Mr. Preece's experiment and my own as due to the same cause. I think also that it is quite possible that we might be able to hear ticks in a wire far too thick for the reproduction of music.

I have begun some experiments with a view to throw some light on questions of this kind. Possibly in the meantime Dr. Ferguson, Mr. Preece, or some other experimenter may be able to produce facts that settle the matter beyond the possibility of doubt.

G. CHRYSTAL

15, Chalmers Street, Edinburgh, June 12

[1] Iron may be anomalous on account of its powerful magnetic properties; and Prof. Tait has suggested that, at a certain high temperature, it may, for well-known reasons, be incapable of producing these effects altogether.

The Aurora Borealis and its Colours

IN reference to Mr. Backhouse's letter last week (p. 145) we have n where stated that "similarity in colour in electric discharges is sufficient to indicate similarity of constitution, even when their spectra are quite unlike" If Mr. Backhouse will again read our paper on the Auroræ, he will see that we say that in the same gas the colour of the discharge varies with the degree of exhaustion. In the *Phil. Trans.*, 1878, part 1, we have shown also that in the same gas at the same pressure the colour of the discharge varies with the amount of current; at pp. 180–181, for example, the strata in hydrogen at a pressure of 1·2 mm., 1579 M, were of a cobalt blue with a current of 0·019940 W, and pink with a current of 0·008504 W. In the index at p. 239 are given several references to the same phenomena; and at p. 240 references are given to a number of observations on the "spectra of strata and of glow on terminals."

It is very difficult to say for certain whether the red is below or above the green in aurora displays, by eye estimation; for although apparently above it may be really below. We adhere to our opinion that the red is at the lower level.

WARREN DE LA RUE
73, Portland Place, W. HUGO MÜLLER

On some Points Connected with Terrestrial Magnetism

IN NATURE, vol. xxii. p. 147, our friend Prof. Balfour Stewart makes the following statement in paragraph γ:—

"Above this again we have the lower strata of the atmosphere, which are non-conductors, while above this we have the upper strata, which are conductors."

We venture to think that our researches prove that air cannot, at any degree of attenuation, be considered as a conductor of electricity in the ordinary acceptation of the term.

In the *Phil. Trans.*, Part I. p. 168, after citing a number of experiments bearing on this point, we say:—"These observations show clearly that the discharge through rarefied gases cannot be at all analogous to conduction through metals; for a wire having a given difference of potential between its ends can permit one—and only one—current to pass; whereas we see that with a given difference of potential between the terminals of a vacuum tube currents of strengths varying from 1 to 135 can flow. We are therefore led to the conclusion that the discharge in a vacuum tube does not differ materially from that in air and other gases at ordinary atmospheric pressure, that it is, in fact, a disruptive discharge."

In Part III. of our researches (an abstract of part of which appears in the same number of NATURE), *Phil. Trans.*, vol. clxxi. p. 82, we sum up a series of experiments on the electric discharge in various gases by stating that the same law holds good for a constant pressure and varying distance between flat terminals as for a constant distance and varying pressure, the obstacle in the way of a discharge being, up to a certain point, as the number of molecules intervening between the terminals.

The hyperbolic curves laid down to represent the observations in each case are perfectly continuous, and show no break from the condition of a non-conductor to that of a conductor.

WARREN DE LA RUE
June 21 HUGO MÜLLER

Calcareous Concretions in Timber

IN NATURE, vol. xxi. p. 376, I observe that in a remark of the reviewer, and also in an extract from Mr. Ball's "Jungle Life in India," the occurrence of concretions of lime in trees is spoken of as a rare and novel phenomenon. That *Terminalia tomentosa* contains calcareous matter has long been known to natives, and a reference to Tennent's "Ceylon," i. 99, will show that they make a practical use of their knowledge by using the ashes of the bark as a substitute for lime, to chew with betel. Another southern tree which contains an alkali in its bark is *Avicennia tomentosa*. It generally grows along the margins of backwaters,